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DEVELOPMENT OF A NOVEL STANDARD NOTION FOR THE IMAGE CONTRAST ENHANCEMENT PERFORMANCE MEASURE

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ABSTRACT

Image enhancement methods are widely used for improving the feature and quality of the images. Image enhancement is to improve the visual appearance of an image or modify attributes of an image to make it more suitable for a specific application. Using local enhancement technique mean brightness of an image may loss and hence high computational time for enhancing the image. These limitations can be overcome by contrast enhancement. In Image enhancement, image contrast enhancement brings out hidden features of an image. Contrast enhancement changing the pixels intensity of the input image to utilize maximum possible bins. We need to study and review different image contrast enhancement performance measuring techniques because contrast losses the brightness in enhancement of image. In this research we did quantification of contrast level for many general and biomedical images. We considered two novel methods under evaluation: first metric is Histogram Flatness Measure (HFM) and second metric is Histogram Spread (HS). Simulation results are done extensively on various images and we found that HS is more reasonable than HFM. We found that even low contrast images are having high value of HFM in some images than original images instead of having low value of HFM, being inconsistent. But in case of HS, for all images HS value is low for low contrast, while for high contrast images HS value is higher than original images; which found to be consistent. So we found HS to be highly useful for standardizing the notion "low contrast low value; high contrast high value"; and HS is highly useful to distinguish between images of different contrast level. The accuracy of the metric is also verified for general and biomedical images. The standardization of the consistency for HS; is having high usefulness in image database management, visualization, image classification.

KEYWORDS: Histogram, Image Contrast, Image Enhancement, Histogram Equalization.

INTRODUCTION

The perceptibility of objects in the scene can be improved by contrast enhancements by enhancing the brightness difference between objects and their backgrounds. In contrast enhancement, contrast stretch improves the brightness uniformly across the dynamic range of image; tonal enhancements improve the brightness differences in the shadow (dark), midtone (grays), or highlight (bright) regions at the expense of the brightness differences in the other regions [1,2,20,21]. Image contrast enhancement is a fundamental pre-processing step in application requiring image processing operation-image enhancement plays a significant role in the field of digital image processing applications, to enhance the apparent visual quality of information contained in an image and makes it easier for visual interpretation, understanding as well as image features process and analysis by computer vision system. When we increase the contrast of an image and filter it to remove the noise it looks better. The technique of contrast enhancement performs quite well with images having a uniform spatial distribution for grey values [19, 20, 3, 5, 8]. Image contrast enhancement techniques are applicable in many real world applications such as medical imaging, geophysical prospecting, aerial and ocean imaging, sensors and instrumentation, LCD display, optics, surveillance [7, 10, 22, 18]. One of the most popular image enhancement methods is histogram equalization (HE) specifically HE is used for image contrast enhancement, as HE is computationally fast and simple to implement. Contrast enhancement plays an important role in image enhancement, it automatically brightness images that appear dark or hazy and applies appropriate tone correction to deliver improved quality and clarity [11, 14, 15]. Contrast enhancement will be used to perform adjustment on darkness or brightness of the image. It mainly used to bring out the feature hidden in an image or increase the contrast of low contrast image.

Image contrast enhancement is one of the most important image enhancement methods. Contrast enhancement is categorized into two methods: direct methods and indirect methods. In case of indirect methods, the histogram

modification techniques have been widely utilized because of its simplicity and explicitness in which histogram equalization is one of the most frequently used technique; in which dynamic range of the image can be fully exploited [18, 19, 20]. Contrast enhancement is based on five techniques such as local, global, partial, bright and dark contrast [22, 17, 18]. It is known that the shape of histogram can indicate the global characteristics of the image: dark, bright, low contrast, high contrast [20, 1, 9]. Many post processing procedures such as histogram equalization, histogram specification and histogram stretching. Main problem is to identity whether the contrast enhancement is needed for the images or not [18, 19, 20]. Contrast enhancement of a good image many lead to an overexposed or saturated image. So we need a metric which can effectively quantify the contrast and thereby discriminate the good and poor contrast images [17, 18, 19]. So we have considered two proposed methods under evaluation; to identify which one is best for developing a sure approach and a metric of notion of "low contrast low value and high contrast high value" [20, 21, 18, 19]. The approaches we have considered are histogram flatness measure (HFM) and histogram spread (HS). We did extensive application on plenty of general and biomedical images and HS found to be best and sure approach as a performance metric which follows the notion "low contrast low value; high contrast high value".
The section II briefly describes the HS and HFM, then section III gives result analysis, and section IV concludes the research.

HFM And HS

Image quality assessment in digital domain is critical in all applications of image processing. Image enhancement provides to enhance the apparent visual quality of an image or emphasize certain features based on the knowledge of source of degradation. Image contrast is an important feature of image enhancement. Here in this research we have taken into consideration of two novel methods under evaluation and applied on plenty of images. Those two novel techniques under evaluation are

1. Histogram Flatness Measure (HFM)
2. Histogram Spread (HS)

These two we have utilized for image contrast enhancement performance analysis to have a sure quantifying measure for the notion **"low contrast low value; high contrast high value".** These two techniques HFM and HS are based on the statistical parameters of image histogram like geometric mean, quartile distance and range [20, 21, 19, 22].

Histogram Flatness Measure (HFM):

It follows in parallel to Spectral Flatness Measure. For our images of interest digital images, we define here HFM as
HFM = (geometric mean of histogram count) / (arithmetic mean of histogram count)

$$HFM = [(\prod_{i=1}^{n} x_i)^{1/n}]/[1/n \sum_{i=1}^{n} x_i] \quad (1)$$

x_i – Histogram count for the i^{th} histogram bin
n – Total number of histogram bins

As per the formula HFM € [0, 1]; and also it is clear that low contrast images have low value of HFM with respect to high contrast images.

Histogram Spread (HS):

HS = (Quartile Distance of Histogram)/(Possible Range of Pixel Values)
= [(3rd Quartile – 1st Quartile) of Histogram] / [(maximum – minimum) of the pixel value range]
3rd quartile means that histogram bins at which cumulative histogram has 75% of the maximum value
1st quartile means that histogram bins at which cumulative histogram have 25% of the maximum value
Range is the difference between the possible maximum and minimum intensities of the image. HS ranges from (0, 1]; for unimodal to multimodal histograms. It is clear that low contrast images have low value of HS with respect to high contrast images.

SIMULATION RESULTS

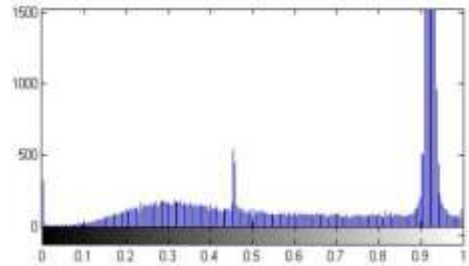
(a)

(b)

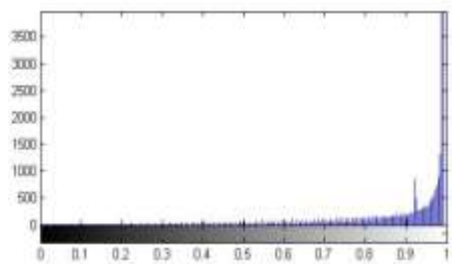
(c)

(d)

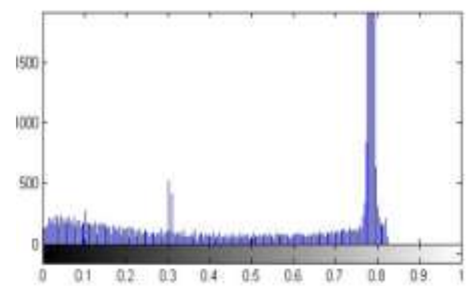
Figure 1. Brain Image (a) Original Image (b) Low Contrast Dark Image (c) Low Contrast Bright Image (d) High Contrast, towards to histogram equalization



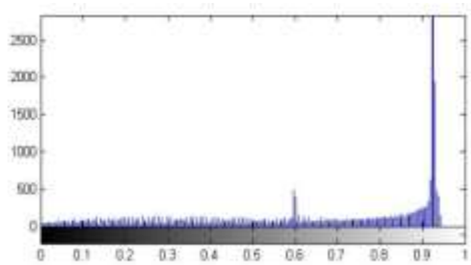
(a)



(b)



(c)



(d)

Figure 2. Brain Image Histograms (a) Original Image (b) Low Contrast Dark Image (c) Low Contrast Bright Image (d) High Contrast, towards histogram equalization

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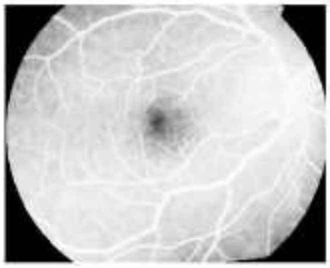
(a)

(b)



(c)

(d)

Figure 3. Retinal Image (a) Original Image (b) Low Contrast Dark Image (c) Low Contrast Bright Image (d) High Contrast, towards histogram equalization

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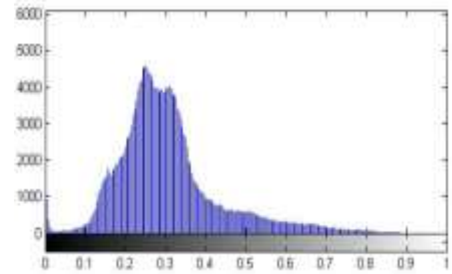
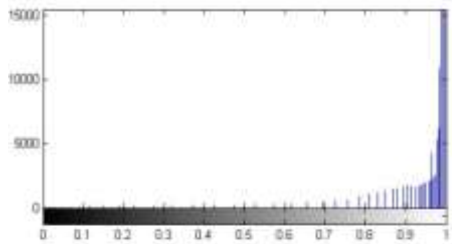
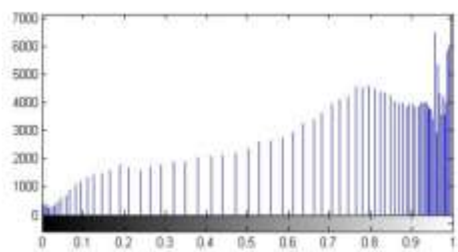


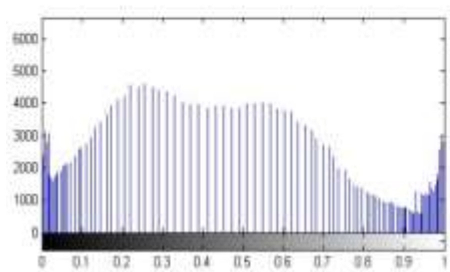
(a)



(b)



(c)



(d)

Figure 4. Retinal Image Histograms (a) Original Image (b) Low Contrast Dark Image (c) Low Contrast Bright Image (d) High Contrast, towards histogram equalization

For evaluating the performance metrics for image contrast enhancement, the HFM and HS are considered for various images such as Brain Image (Figure 1), Retinal Image (Figure 2) and for plenty more images given in Figure 5: a. brain image 1 b. brain image 2 c. Brain Shepp-Logan phantom image d. Lena Image e. cycle tree cave image by using their various Histograms. Here for example purposes we are giving the various levels of intensities of the images and their corresponding histograms for Brain Image and Retinal Image in Figure 1 and Figure 3 along with their corresponding Histograms in Figure 2 and Figure 4. The corresponding tables of quantitative analysis results for the image contrast performance metrics for standardizing a sure notion: HFM and HS values are given in Table 1 and Table 2 for the Histogram bins of the corresponding images.

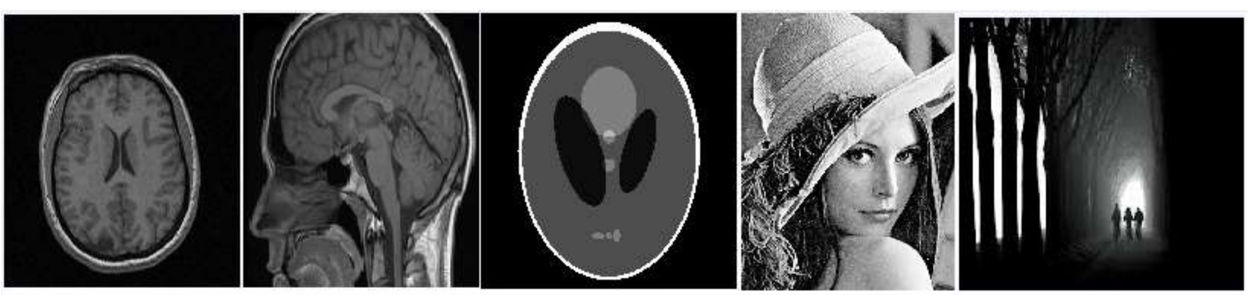
Serial Number	Image Name	Original	Low Contrast (dark)	Low Contrast (bright)	High Contrast (histogram equalized)
1	Brain image	0.5678	0.5778	0.6789	0.7910
2	Retinal image	0.6789	0.3456	0.6799	0.7890
3	Brain image 1	0.7896	0.2341	0.7654	0.8345
4	Brain image2	0.5432	0.4567	0.4567	0.5789
5	Brain phantom	0.7865	0.4356	0.7989	0.8787
6	Len image	0.6754	0.3432	0.5672	0.6980
7	Cycle tree cave	0.5643	0.1234	0.4512	0.6732

Table 1. Histogram Flatness Measure (HFM) For Test Images for Different Contrast Condition

Serial Number	Image Name	Original	Low Contrast (dark)	Low Contrast (bright)	High Contrast (histogram equalized)
1	Brain image	0.3421	0.1245	0.2345	0.4456
2	Retinal image	0.4321	0.2345	0.2876	0.4897
3	Brain image 1	0.4456	0.3346	0.3567	0.4567
4	Brain image2	0.3324	0.2134	0.2234	0.4502
5	Brain phantom	0.3432	0.2363	0.2678	0.4034
6	Len image	0.4834	0.2345	0.3980	0.4987
7	Cycle tree cave	0.4567	0.2387	0.2234	0.4908

Table 2. Histogram Spread (HS) for test images for different contrast condition

In the Table 1, the results for HFM values for various images have been tabulated. In this table it is observed that for low contrast images also we are having higher HFM values which is violating the notion **"low contrast low value; high contrast high value".** But as per the high contrast images it is sure that the HFM values are higher than original image. But in the case of low contrast images it is sometimes violating the notion. Here we showed the table for 7 different



(a) (b) (c) (d)
(e)

Figure 5. Few more images we have put into application a. brain image 1 b. brain image 2 c. Brain Shepp-Logan phantom image d. Lena Image e. cycle tree cave image

Subjects, but originally for plenty of various more images are also observed, including some general images and biomedical images. It is observed clearly that HFM is violating the notion in some cases and found to be somewhat inconsistent and not giving us surety.

But when we observe the results in Table 2 for HS, it is surely following the notion and following consistency as per the required notion. We observed it for plenty of different images. So HS is surely observed to be consistent and having high usefulness in observing the performance of the image contrast enhancement when compared to the HFM.

CONCLUSION

In this research we observed the simulation results for two performance measures under evaluation for image contrast enhancement for general and biomedical images: HFM and HS. The simulation results reveal that out of these two measures HS found to be consistent and following the desired notion **"low contrast low value; high contrast high value"** and highly meaningful than HFM. Considering histogram bin locations specifically as part of HS can be the reason for this. HS can discriminate effectively low and high contrast images, is a very useful result. Basing on the measured quantitative value we can identify for the given image how much image contrast is required and also whether required or not.

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